Proton irradiation of gold targets for $^{197(m)}$Hg production

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Introduction

Irradiation of gold with protons provides access to no-carrier-added ^{197m}Hg and ^{197}Hg. Interests in these radionuclides were awakened by the unique chemical and physical properties of mercury and its compounds combined with convenient nuclear properties like suitable half life (^{197m}Hg: $T_{1/2}$ = 23.8 h, ^{197}Hg: $T_{1/2}$ = 64.14 h), low energy gamma radiations for imaging, Auger – and conversion electrons for therapy. The high thermal conductivity of gold enables high current irradiations and the monoisotopic natural abundance of ^{197}Au supersedes expensive enrichment of the target material. The ^{197}Au(p,n)$^{197(m)}$Hg reaction was applied until now only for beam monitoring[1], stacked foil measurements[2] or very small scale tracer production.[3]

Material and Methods

The irradiations were performed at a Cyclone 18/9 (IBA, Louvain la Neuve, Belgium). Its beamline was sealed with a 1.0 mm vacuum foil (high purity aluminum, 99.999 %) from Goodfellow (Huntingdon, England). High purity gold disks (23 mm diameter, 2 mm thickness, 99.999% pure, 1 ppm Cu) as target material were purchased from ESPI (Ashland, USA). Gold foils as alternative gold targets (12.5×12.5 mm, 0.25 mm thickness, 99.99+ %, 1 ppm Cu) between an aluminum disk (22 mm diameter, 1 mm thickness, 99.0 %, hard) and an aluminum lid (23 mm diameter, 99.0 %, hard) were purchased from Goodfellow (Huntingdon, England). Hydrochloric acid (30%) and nitric acid (65%) were purchased from Roth (Karlsruhe, Germany) in Rotipuran® Ultra quality. Deionized water with > 18 MΩcm resistivity was prepared by a Milli-Q® system (Millipore, Molsheim, France). For separation of target material and side products a liquid-liquid extraction method (Gold was extracted with methyl isobutyl ketone (MIBK) from 2 M HCl target solution) and an ion exchange method (cation exchange resin (Dowex50W-x8, 100–200 mesh, H^+ form) were applied.

Results and Conclusion

No-carrier-added $^{197(m)}$Hg was produced from gold via the ^{197}Au(p,n)$^{197(m)}$Hg reaction at proton energies of 10 MeV in sufficient quantity and quality for imaging studies.

Two different methods were studied for the separation of Hg radionuclides generated from Au targets. The results demonstrate the possibility to produce $^{197(m)}$Hg from gold at low proton energies. Combined with the presented radiochemical separation methods, the ^{197}Au(p,n) reaction could be the basis for repeatable production of $^{197(m)}$Hg for imaging and therapy research on sufficient activity level.

t_{irr} (h)	I_T (µA)	A_{EOB} (MBq) ^{197}Hg	^{197m}Hg	^{196}Au	^{198}Au
1	25	56.52	55.35	<0.011	0.054
1.5	25	113.85	96.30	<0.005	0.081
1	25	67.51	51.75	<0.012	0.045

TABLE 1. Activities of products and side products in dissolved target material at EOB

References

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